WHAT IS CLAIMED IS:

1. A plasma processing system for processing a workpiece, the plasma processing system comprising:

a plasma chamber including an interior region for supporting a plasma;

at least one electrode assembly mounted within said plasma chamber;

at least one RF power source electrically coupled to said at least one electrode assembly through at least one transmission line;

at least one voltage probe coupled to said at least one transmission line and configured to measure a voltage at said at least one electrode assembly; and

a control system electrically coupled to said at least one voltage probe, and said at least one RF power source, the control system being configured to determine an ion energy of plasma ions striking the workpiece over a voltage bias period to improve the performance of the plasma processing system.

2. The plasma processing system as recited in claim 1, wherein said control system is further configured to determine an ion energy distribution function (IEDF) of plasma ions striking the workpiece over a voltage bias period to improve the performance of the plasma processing system.

3. The plasma processing system as recited in claim 1, wherein said at least one electrode assembly comprises a first electrode assembly and a second electrode assembly, wherein said first electrode assembly is mounted on a first side of the plasma chamber and said second electrode assembly is mounted on a second side of the plasma chamber opposite the first side of the plasma chamber and spaced from the first electrode assembly.

4. The plasma processing system as recited in claim 3, wherein said first electrode assembly and said second electrode assembly comprise a plurality of electrode segments, each segment being electrically isolated from the other segments and at least

two segments being independently powered by an associated RF power source for transmission of RF power into the interior of the plasma chamber.

5. The plasma processing system as recited in claim 3, wherein said first electrode assembly and said second electrode assembly comprise a plurality of electrode segments, at least two segments being independently supplied with a selected processing gas for transmission into the interior of the plasma chamber.

6. The plasma processing system as recited in claim 1, wherein said plasma processing system further comprises an optical probe coupled to the plasma chamber and to the control system, the optical probe being configured to determine plasma characteristics and conditions based on spectral and optical properties of the plasma.

7. The plasma processing system as recited in claim 1, wherein the at least one electrode assembly comprises at least one of a grounded chamber wall, a grounded electrode assembly, a DC biased electrode assembly, an AC biased electrode assembly, a DC biased chamber wall, and an AC biased chamber wall.

8. A method for determining the potential of a plasma generated in a plasma chamber utilizing at least one electrode assembly disposed in said plasma chamber, comprising:

a) applying at least one signal to the at least one electrode assembly;

b) measuring at least one voltage, wherein said measuring at least one voltage comprises determining a measured voltage for each plasma engaging surface;

c) determining a highest measured voltage by comparing the measured voltages corresponding to plasma engaging surfaces; and

d) equating the highest measured voltage to the plasma potential, the plasma potential at a particular instant in time being equal to the highest measured voltage observed for any of the plasma engaging surfaces that are interacting with the plasma at the particular instant.

9. The method for determining the potential of a plasma as recited in claim 8, said at least one electrode assembly comprising first and second electrode assemblies, said measuring at least one voltage comprising determining a first measured voltage corresponding to the plasma engaging surface of the first electrode assembly and a second measured voltage corresponding to the plasma engaging surface of the second electrode assembly, and the method further comprising equating the plasma potential to the more positive voltage of the first measured voltage and the second measured voltage.

10. The method for determining the potential of a plasma as recited in claim 8, said measuring further comprising measuring voltages at points in time; said determining the highest voltage further comprising determining a highest measured voltage at each point in time; said equating further comprising equating the highest measured voltage to the plasma potential at each point in time; and the method further comprising generating a waveform representing the plasma potential at each point in time.

11. A method for determining the energy of a plasma ion current striking a workpiece in a processing chamber, and the plasma being biased by a plurality of electrodes in the chamber, one said electrode supporting the workpiece, a respective voltage signal being electrically communicated to each said electrode, the method comprising:

determining the voltage of a plasma engaging surface of each electrode of said plurality of electrodes at sample points for a period of time;

determining a maximum electrode voltage during each sample point for each of said plurality of electrodes;

determining a waveform representing the plasma potential for the period of time, the waveform being determined utilizing the maximum electrode voltage of each of said plurality of electrodes measured during each sample point; and

determining the ion energy of the ion current striking the workpiece.

12. The method for determining the energy of a plasma ion current as recited in claim 11, wherein the period of time is equal to the period when the plasma is being biased by the plurality of electrodes in the chamber.

13. The method for determining the energy of a plasma ion current as recited in claim 11, wherein the period of time is less than the period when the plasma is being biased by the plurality of electrodes in the chamber.

14. The method for determining the energy of a plasma ion current as recited in claim 11, wherein the period of time is more than the period when the plasma is being biased by the plurality of electrodes in the chamber.

15. The method for determining the energy of a plasma ion current as recited in claim 11, wherein said determining the ion energy comprises calculating a difference function at each sample point where the difference function is the difference between the plasma potential and the potential of the one said electrode supporting the workpiece; and determining an ion energy using the product of the voltage difference value and the charge on an electron at each sample point, wherein the determination of the ion energy assumes a spatially homogeneous plasma.

16. The method for determining the energy of a plasma ion current as recited in claim 11, wherein the method further comprises determining a total amount of energy of the ions striking the workpiece in said period of time.

17. The method for determining the energy of a plasma ion current as recited in claim 11, wherein determining a total amount of energy comprises determining an ion current; and multiplying the ion energy by the number density of ions n_i wherein n_i is related to the ion current by $J_i=0.61Aen_iv_B$, wherein A is the substrate surface area, $v_B=(eT_e/M)^{1/2}$ is the Bohm velocity, T_e is the electron temperature and M is the ion mass.

18. The method for determining the energy of a plasma ion current as recited in claim 16, further comprising determining the ion energy distribution function (IDEF) of the ion current striking the workpiece.

19. The method for determining the energy of a plasma ion current as recited in claim 18, wherein the determining of the ion energy distribution function comprises constructing a waveform of the plasma potential, constructing a waveform for the ion energy; and determining an ensemble averaged E(t) using a graph of energy (y-axis) vs. time (x-axis).

20. A machine readable medium encoded with a program for determining an ion energy distribution function of a plasma contained in a chamber using a processing system, at least two electrodes being mounted in said chamber, one electrode of said at least two electrodes supporting a workpiece, each electrode having a plasma engaging surface in contact with said plasma and each electrode being electrically communicated to a respective voltage signal, said program causing said processing system to:

determine the voltages of the respective plasma engaging surfaces of each electrode at a predetermined sample rate for a predetermined sample period to provide samples of said voltages at sample points during said sample period;

determine the plasma potential at each said sample point by selecting the greatest electrode voltage;

determine a plasma potential waveform for said plasma utilizing said sampled plasma potentials;

determine an ion energy waveform of said plasma utilizing the plasma potential waveform; and

determine the ion energy distribution function of said plasma utilizing the ion energy waveform.

21. A method for determining the potential of a plasma generated in a plasma chamber utilizing at least one electrode assembly disposed in said plasma chamber, wherein said plasma chamber comprises a plasma engaging surface having a measured voltage of ground potential, the method comprising:

a) applying at least one signal to the at least one electrode assembly;

b) measuring at least one voltage, wherein said measuring at least one voltage comprises determining a measured voltage for each of said at least one electrode assembly that comprises a plasma engaging surface;

c) determining a highest measured voltage by comparing the measured voltages corresponding to plasma engaging surfaces; and

d) equating the highest measured voltage to the plasma potential, the plasma potential at a particular instant in time being equal to the highest measured voltage observed for any of the plasma engaging surfaces that are interacting with the plasma at the particular instant.

22. A method for determining the potential of a plasma generated in a plasma chamber utilizing at least one plasma engaging surface, the method comprising:

a.) measuring at least one voltage, wherein said measuring at least one voltage comprises determining a measured voltage for each of the at least one plasma engaging surface;

b.) determining a highest measured voltage by comparing the measured voltage corresponding to each of the at least one plasma engaging surface; and

c.) equating the highest measured voltage to the plasma potential, the plasma potential at a particular instant in time being equal to the highest measured voltage observed for any of the at least one plasma engaging surfaces that are interacting with the plasma at the particular instant.

23. A method for determining the potential of a plasma as recited in claim 22, wherein the at least one plasma engaging surface comprises at least one of a grounded chamber wall, a grounded electrode assembly, a DC biased electrode assembly, an AC biased electrode assembly, a DC biased chamber wall, and an AC biased chamber wall.